PAMS Technical Documentation
NSM–5 Series Transceivers

System Module

Issue 1 02/2002
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Transceiver NSM–5

Introduction

The NSM–5 is a dual band transceiver unit designed for the GSM900 (including EGSM) and GSM1800 networks. It is both GSM900 phase 2 power class 4 transceiver (2W) and GSM1800 power class 1 (1W) transceiver.

The transceiver consists of System/RF module (DF7), Display module (UX7) and assembly parts.

The transceiver has a full graphic display and the user interface is based on a Jack style UI with two soft keys.

A back mounted antenna is used, there is no connection to an external antenna.

The transceiver has a low leakage tolerant earpiece and an omnidirectional microphone located in the mainframe, providing an excellent audio quality. The transceiver supports a full rate, an enhanced full rate and a half rate speech decoding.

An integrated IR link provides a connection between two NSM–5 transceivers or a transceiver and a PC (internal data), or a transceiver and a printer.

The small SIM (Subscriber Identity Module) card is located below the back cover of the phone.

Operation Modes

There are five different operation modes:

– power off mode

– idle mode

– active mode

– charge mode

– local mode

In the power off mode only the circuits needed for power up are supplied.

In the idle mode circuits are powered down and only sleep clock is running.

In the active mode all the circuits are supplied with power although some parts might be in the idle state part of the time.

The charge mode is effective in parallel with all previous modes. The charge mode itself consists of two different states, i.e. the fast charge and the maintenance mode.

The local mode is used for alignment and testing.

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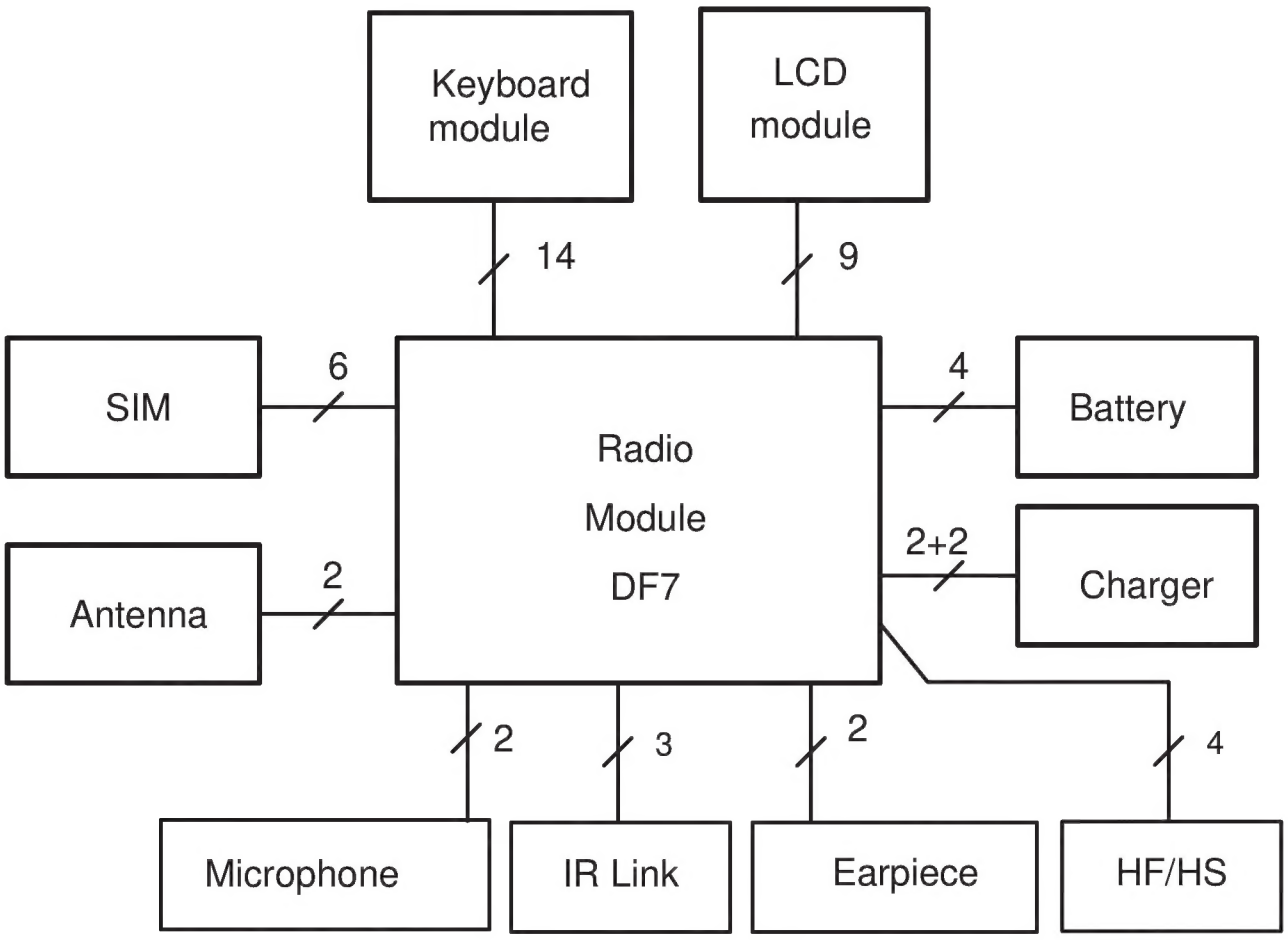
Interconnection Diagram



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System Module

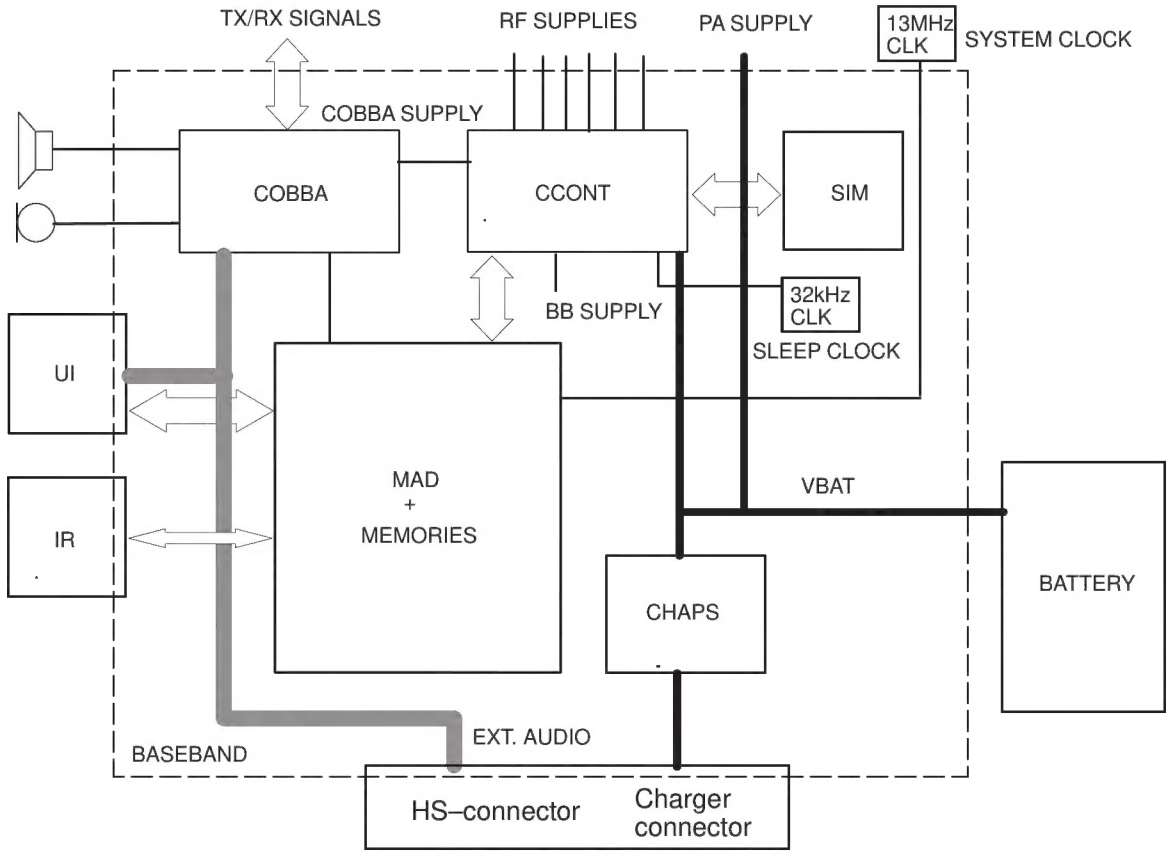
Baseband Module

The baseband architecture supports a power saving function called ”sleep mode”. This sleep mode shuts off the VCTCXO, which is used as system clock source for both RF and baseband. During the sleep mode the system runs from a 32 kHz crystal. The phone is waken up by a timer running from this 32 kHz clock supply. The sleeping time is determined by some network parameters. The sleep mode is entered when both the MCU and the DSP are in standby mode and the normal VCTCXO clock has been switched off.

The battery charging is controlled by a PWM signal from the CCONT. The PWM duty cycle is determined by a charging software and is fed to the CHAPS charging switch.

Standard chargers (two wires) provide coarse supply power, which is switched by the CHAPS for suitable charging voltage and current. Advanced chargers (three wires) are equipped with a control input. Three wire chargers are treated like two wire ones.

Block Diagram



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Technical Summary

The baseband module consists four ASICs; CHAPS, CCONT, COBBA–GJP and MAD2WD1, which take care of the baseband functions of the engine.

The baseband is running from a 2.8V power rail, which is supplied by a power controlling ASIC CCONT. In the CCONT there are 6 individually controlled regulator outputs for RF–section and two outputs for the baseband. In addition there is one +5V power supply output (V5V). The CCONT contains also a SIM interface, which supports both 3V and 5V SIM–cards. A real time clock function is integrated into the CCONT, which utilizes the same 32kHz clock supply as the sleep clock. A backup power supply is provided for the RTC, which keeps the real time clock running when the main battery is removed. The backup power supply is a rechargable battery. The backup time with the battery is ten minutes minimum.

The interface between the baseband and the RF section is mainly handled by a COBBA ASIC**.** COBBA provides A/D and D/A conversion of the in–phase and quadrature receive and transmit signal paths and also A/D and D/A conversions of received and transmitted audio signals to and from the user interface. The COBBA supplies the analog TXC and AFC signals to RF section according to the MAD DSP digital control. Data transmission between the COBBA and the MAD is implemented using serial bus for high speed signalling and for PCM coded audio signals. Digital speech processing is handled by the MAD ASIC. COBBA is a dual voltage circuit, the digital parts are running from the baseband supply VBB and the analog parts are running from the analog supply VCOBBA.

The baseband supports both internal and external microphone inputs and speaker outputs. Input and output signal source selection and gain control is done by the COBBA according to control messages from the MAD. Keypad tones, DTMF, and other audio tones are generated and encoded by the MAD and transmitted to the COBBA for decoding. A buzzer and an external vibra alert control signals are generated by the MAD with separate PWM outputs.

EMC shieding is implemented using a metallized plastic frame. On the other side the engine is shielded with PWB grounding. Heat generated by the circuitry will be conducted out via the PWB ground planes.

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External and Internal Signals and Connections

This section describes the external electrical connection and interface levels on the baseband. The electrical interface specifications are collected into tables that covers a connector or a defined interface.

DC (charger) connector

DC (charger) connector is physically integrated in the same component with the accessory interface connector. DC connector has both jack and contact pads for desk stand.

Service connector

Name	Parameter	Min	Typ	Max	Unit	Remark
MBUS	Serial clock from the Prommer	0 2.0	logic low logic low	0.8 2.85	V	Prommer detection and Serial Clock for synchronous communication
FBUS_RX	Serial data from the Prommer	0 2.0	logic low logic high	0.8 2.85	V	Receive Data from Prommer to Baseband
FBUS_TX	Data acknowledge to the Prommer	0 2.0	logic low logic high	0.5 2.85	V	Transmit Data from Baseband to Prommer
GND	GND	0		0	V	Ground

The service connector is used as a flash programming interface for updating (i.e. re–programming) the flash program memory and an electrical access for services to the engine.

When the flash prommer is connected to the phone supply power is provided through the battery contacts and the phone is powered up with a pulse given to the BTEMP line.

Battery connector

The BSI contact on the battery connector is used to detect when the battery is to be removed to be able to shut down the operations of the SIM card before the power is lost if the battery is removed with power on. The BSI contact disconnects earlier than the supply power contacts to give enough time for the SIM and LCD shut down.

Name	Min	Typ	Max	Unit	Notes
VBATT	3.0	3.9	4.2	V	Battery voltage
BSI	0		2.85	V	Battery size indication Phone has 100kohm pull up resistor. SIM Card removal detection (Treshold is 2.4V@VBB=2.8V)
	67	68	69	kohm	Battery indication resistor (BLB–2)
		22		kohm	Battery indication resistor (service battery)

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Name	Min	Typ	Max	Unit	Notes
BTEMP	0		1.4	V	Battery temperature indication Phone has a 100k (+–5%) pullup resistor, Battery package has a NTC pulldown resistor: 47k+–5%@+25C , B=4050+–3%
	2.1 5	 10	3 20	V ms	Phone power up by battery (input) Power up pulse width
	1.9 90	 100	2.85 200	V ms	Battery power up by phone (output) Power up pulse width
	0		1	kohm	Local mode initialization (in production)
BGND	0		0	V	Battery ground

SIM card connector

The SIM card connector is located on the engine board beside the battery pack.

Pin	Name	Parameter	Min	Typ	Max	Unit	Notes
4	GND	GND	0		0	V	Ground
3, 5	VSIM	5V SIM Card 3V SIM Card	4.8 2.8	5.0 3.0	5.2 3.2	V	Supply voltage
6	DATA	5V Vin/Vout 3V Vin/Vout 	4.0 0 2.8 0	”1” ”0” ”1” ”0”	VSIM 0.5 VSIM 0.5	V	SIM data Trise/Tfall max 1us
2	SIMRST	5V SIM Card 3V SIM Card	4.0 2.8	”1” ”1”	VSIM VSIM	V	SIM reset
1	SIMCLK	Frequency Trise/Tfall		3.25	 25	MHz ns	SIM clock

RTC backup battery

The RTC block in CCONT needs a power backup to keep the clock running when the phone battery is disconnected. The backup power is supplied from a rechargable polyacene battery that can keep the clock running ten minutes minimum. The backup battery is charged from the main battery through CHAPS.

Signal	Parameter	Min	Typ	Max	Unit	Notes
VBACK	Backup battery charging from CHAPS	3.02	3.15	3.28	V	
	Backup battery charging from CHAPS	100	200	500	uA	Vout@VBAT–0.2V
VBACK	Backup battery supply to CCONT	2		3.28	V	
	Backup battery supply to CCONT		80		uA	

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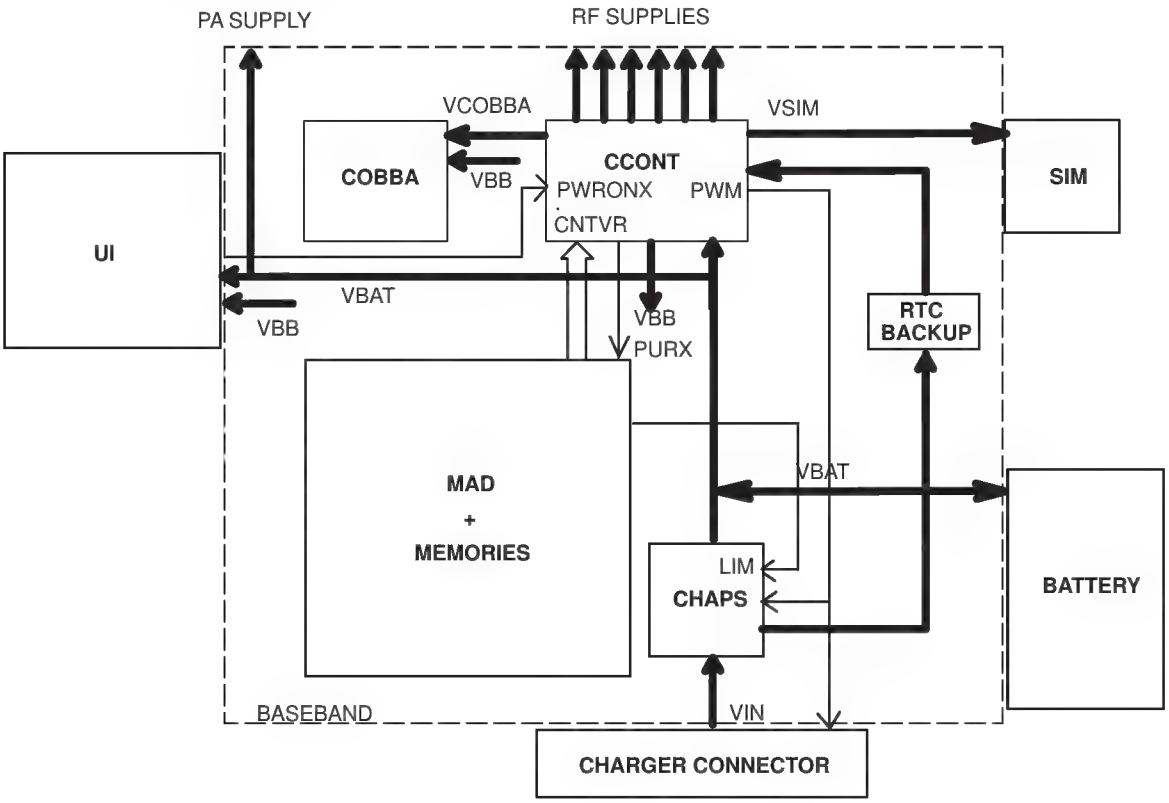
Power Distribution

In normal operation the baseband is powered from the phone's battery. The battery consists of one Lithium–Ion cell. An external charger can be used for recharging the battery and supplying power to the phone.

The baseband contains parts that control power distribution to whole phone excluding those parts that use continuous battery supply. The battery feeds power directly to the CCONT and UI (buzzer and display and keyboard lights).

The power management circuit CHAPS provides protection against overvoltages, charger failures and pirate chargers etc. that would otherwise cause damage to the phone.



Battery charging

The electrical specifications give the idle voltages produced by the acceptable chargers at the DC connector input. The absolute maximum input voltage is 30V due to the transient suppressor that is protecting the charger input. At phone end there is no difference between a plug–in charger or a desktop charger. The DC–jack pins and bottom connector charging pads are connected together inside the phone.

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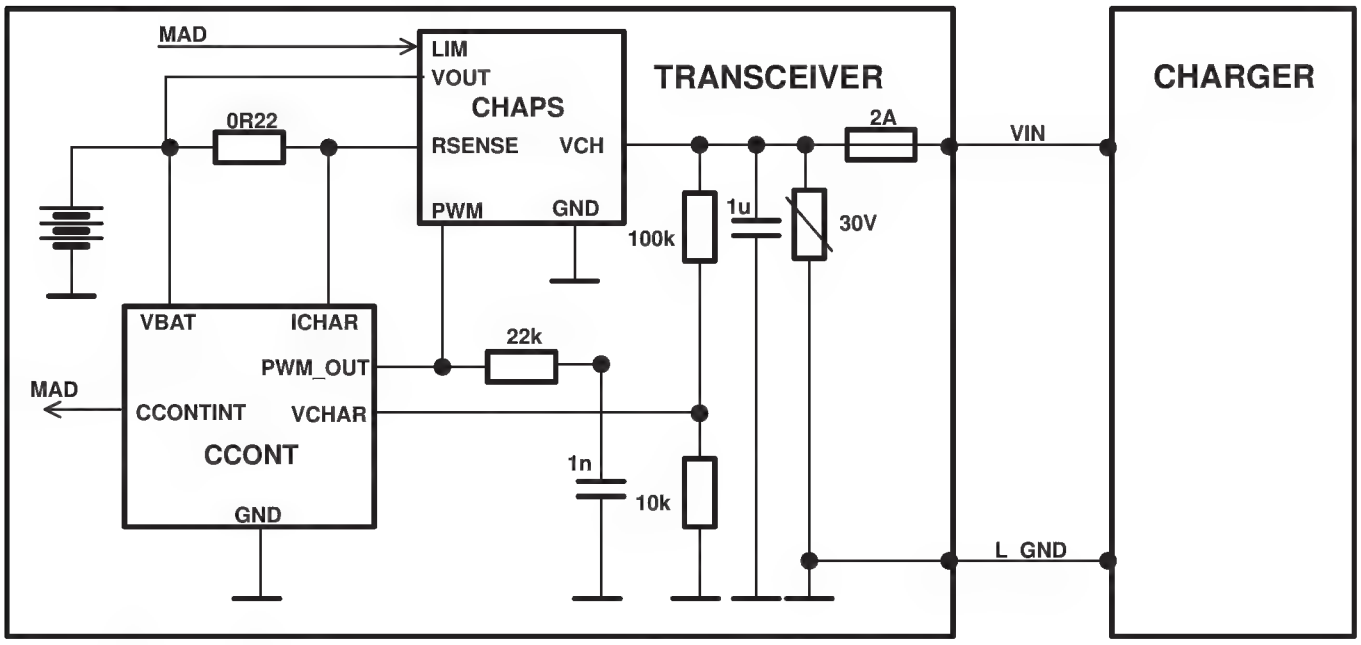

Startup Charging

When a charger is connected, the CHAPS is supplying a startup current minimum of 130mA to the phone. The startup current provides initial charging to a phone with an empty battery. Startup circuit charges the battery until the battery voltage level is reaches 3.0V (+/– 0.1V) and the CCONT releases the PURX reset signal and program execution starts. Charging mode is changed from startup charging to PWM charging that is controlled by the MCU software. If the battery voltage reaches 3.55V (3.75V maximum) before the program has taken control over the charging, the startup current is switched off. The startup current is switched on again when the battery voltage is sunken 100mV (nominal).

Parameter	Symbol	Min	Typ	Max	Unit
VOUT Start– up mode cutoff limit	Vstart	3.45	3.55	3.75	V
VOUT Start– up mode hysteresis NOTE: Cout = 4.7 uF	Vstarthys	80	100	200	mV
Start–up regulator output current VOUT = 0V ... Vstart	Istart	130	165	200	mA

Battery Overvoltage Protection

Output overvoltage protection is used to protect phone from damage. This function is also used to define the protection cutoff voltage for different battery types (Li or Ni). The power switch is immediately turned OFF if the voltage in VOUT rises above the selected limit VLIM1 or VLIM2.

Parameter	Symbol	LIM input	Min	Typ	Max	Unit
Output voltage cutoff limit (during transmission or Li–battery)	VLIM	LOW	4.4	4.6	4.8	V

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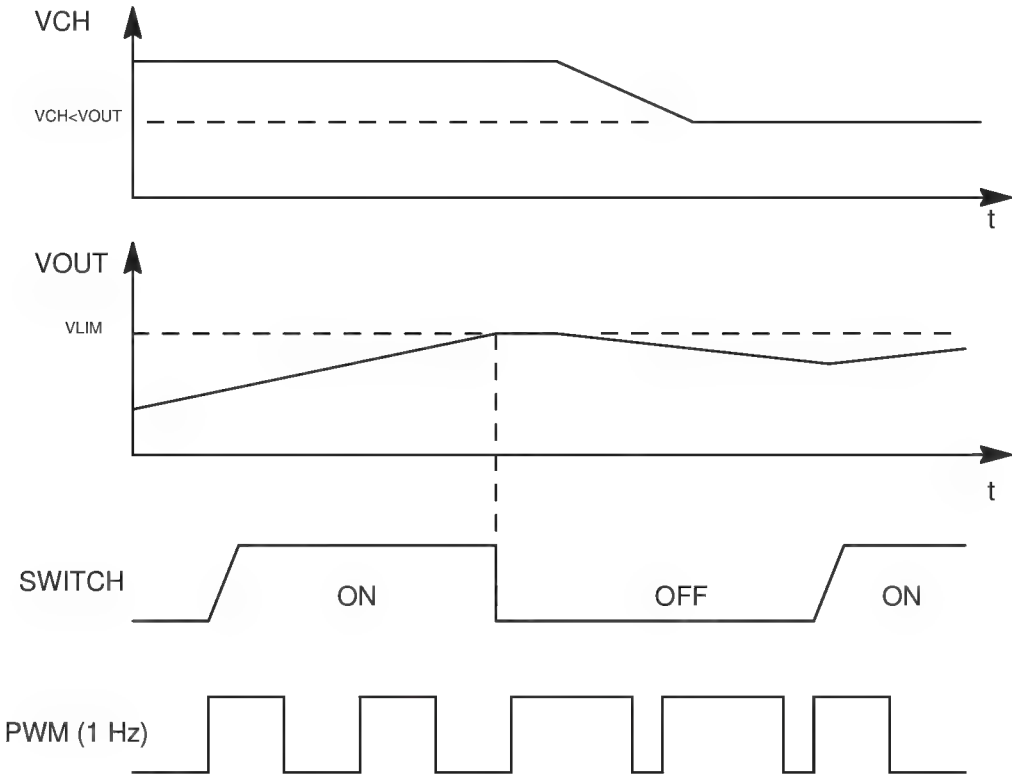
The voltage limit (VLIM1 or VLIM2) is selected by logic LOW or logic HIGH on the CHAPS (N101) VLIM input pin. In NSM–5 VLIM is fixed low in HW.

When the switch in output overvoltage situation has once turned OFF, it stays OFF until the the battery voltage falls below VLIM and PWM = LOW is detected. The switch can be turned on again by setting PWM = HIGH.



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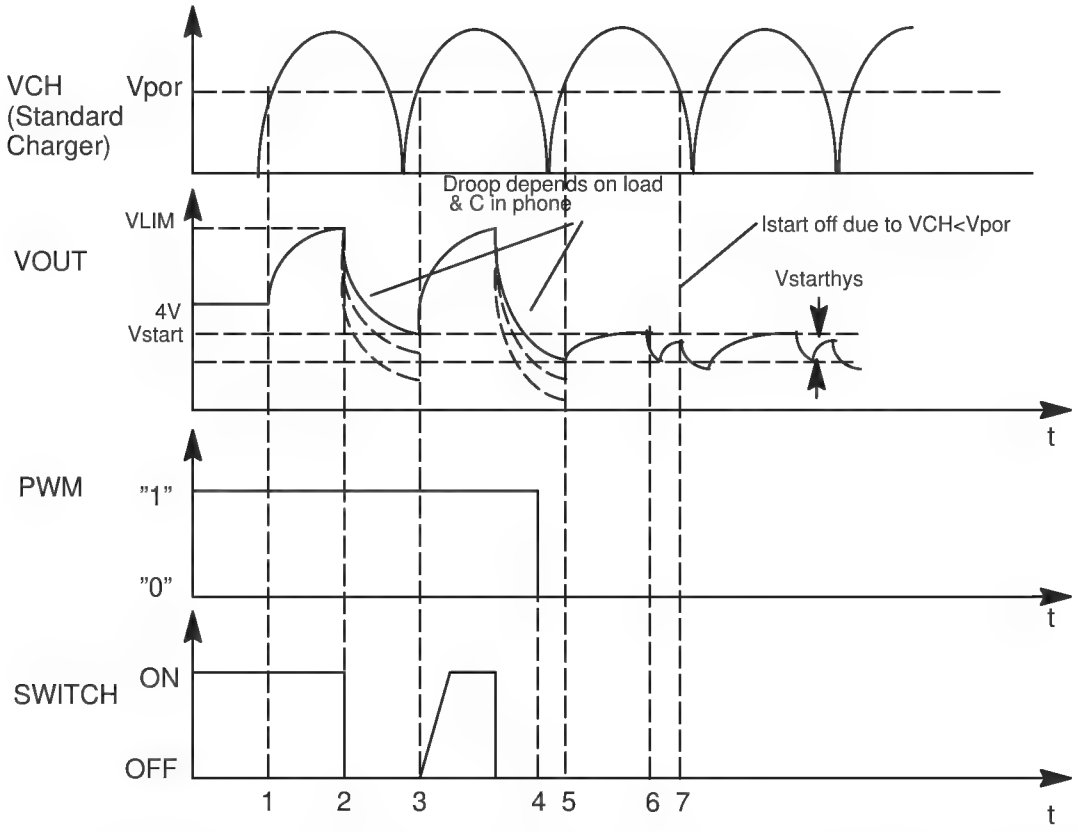
Battery Removal During Charging

Output overvoltage protection is also needed in case the main battery is removed when charger connected or charger is connected before the battery is connected to the phone.

With a charger connected, if VOUT exceeds VLIM, CHAPS turns switch OFF until the charger input has sunken below Vpor (nominal 3.0V, maximum 3.4V). MCU software will stop the charging (turn off PWM) when it detects that battery has been removed. The CHAPS remains in protection state as long as PWM stays HIGH after the output overvoltage situation has occured.



1. Battery removed, (standard) charger connected, VOUT rises (follows charger voltage)
2. VOUT exceeds limit VLIM(X), switch is turned immediately OFF
3. VOUT falls (because no battery) , also VCH<Vpor (standard chargers full–rectified output). When VCH > Vpor and VOUT < VLIM(X) –> switch turned on again (also PWM is still HIGH) and VOUT again exceeds VLIM(X).
4. Software sets PWM = LOW –> CHAPS does not enter PWM mode
5. PWM low –> Startup mode, startup current flows until Vstart limit reached
6. VOUT exceeds limit Vstart, Istart is turned off
7. VCH falls below Vpor

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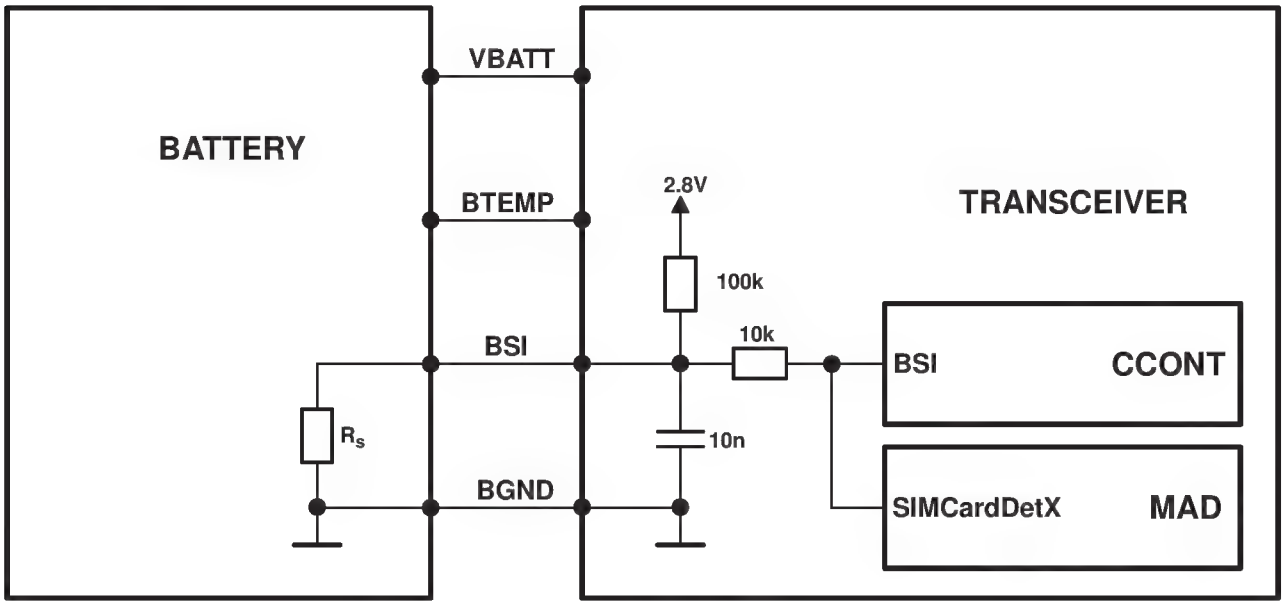
PWM

When a charger is used, the power switch is turned ON and OFF by the PWM input. PWM rate is 1Hz. When PWM is HIGH, the switch is ON and the output current Iout = charger current – CHAPS supply current. When PWM is LOW, the switch is OFF and the output current Iout = 0. To prevent the switching transients inducing noise in audio circuitry of the phone soft switching is used.

Battery Identification

Different battery types are identified by a pulldown resistor inside the battery pack. The BSI line inside transceiver has a 100k pullup to VBB. The MCU can identify the battery by reading the BSI line DC–voltage level with a CCONT (N100) A/D–converter.

Name	Min	Typ	Max	Unit	Notes
BSI	0		2.8	V	Battery size indication 100k pullup resistor to VBB in phone SIM Card removal detection (Treshold is 2.4V@VBB=2.8V)
	67	68	69	kohm	Indication of a BLB–2 battery (650 mAh Li–Ion)
		22		kohm	Indication resistor for a service battery



The battery identification line is used also for battery removal detection. The BSI line is connected to a SIMCardDetX line of MAD2. SIMCardDetX is a threshold detector with a nominal input switching level 0.85xVcc for a rising edge and 0.55xVcc for a falling edge. The battery removal detection is used as a trigger to power down the SIM card before the power is lost. The BSI contact in the battery contact disconnects before the other contacts so that there is a delay between battery removal detection and supply power off.

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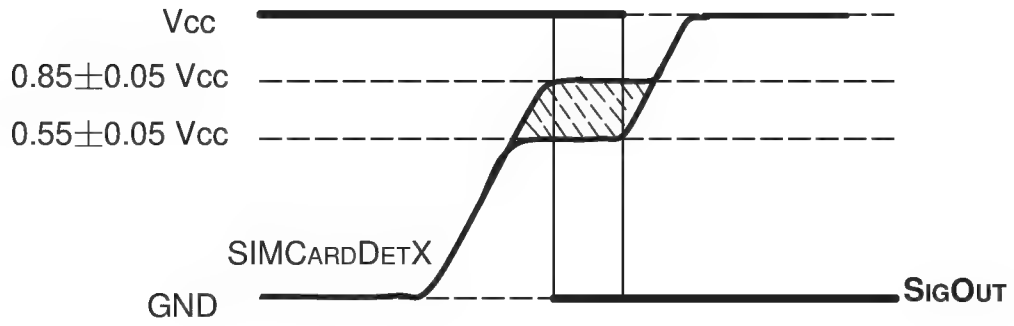
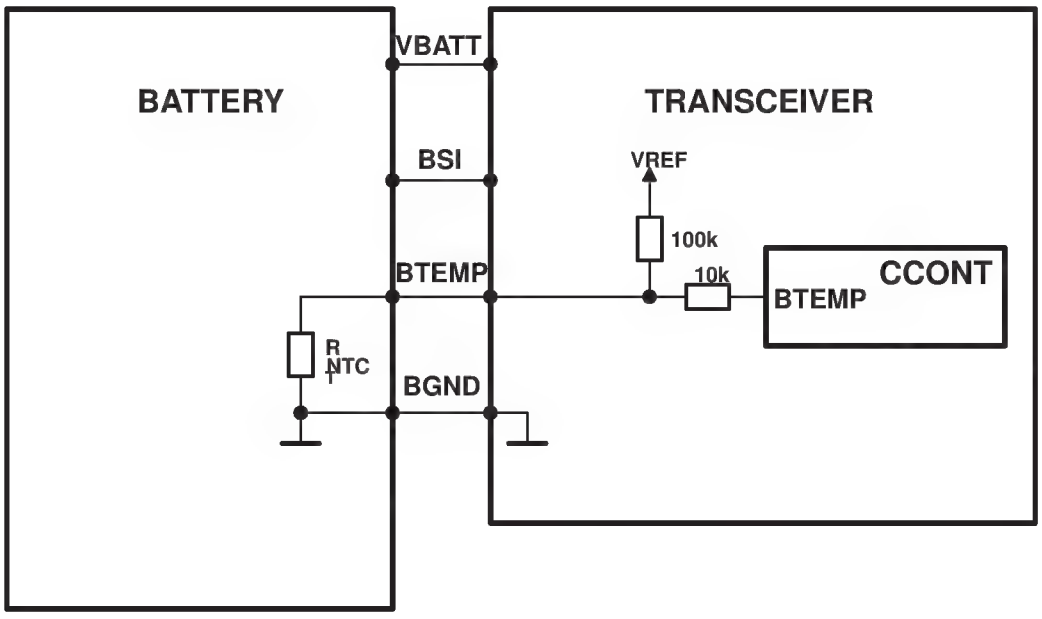


Battery Temperature

The battery temperature is measured with a NTC inside the battery pack. The BTEMP line inside transceiver has a 100k pullup to VREF. The MCU can calculate the battery temperature by reading the BTEMP line DC–voltage level with a CCONT (N100) A/D–converter.

Pin	Name	Min	Typ	Max	Unit	Notes
3	BTEMP	0		1.4	V	Battery temperature indication 100k pullup resistor to VREF in phone Battery package has NTC pull down resistor: 47k +/–5%@+25C , B=4050+/–3%
		2.1		3	V	Phone power up by battery (input)
		5	10	20	ms	Power up pulse width
		1.9		2.8	V	Battery power up by phone (output)
		90	100	200	ms	Power up pulse width
		–5		5	%	100k pullup resistor tolerance



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Supply Voltage Regulators

The heart of the power distrubution is the CCONT. It includes all the voltage regulators and feeds the power to the whole system. The baseband digital parts are powered from the VBB regulator which provides 2.8V baseband supply. The baseband regulator is active always when the phone is powered on. The VBB baseband regulator feeds MAD and memories, COBBA digital parts and the LCD driver in the UI section. There is a separate regulator for a SIM card. The regulator is selectable between 3V and 5V and controlled by the SIMPwr line from MAD to CCONT. The COBBA analog parts are powered from a dedicated 2.8V supply VCOBBA. The CCONT supplies also 5V for RF and for flash VPP. The CCONT contains a real time clock function, which is powered from a RTC backup when the main battery is disconnected. The RTC backup is rechargable polyacene battery. The battery is charged from the main battery voltage by the CHAPS when the main battery voltage is over 3.2V.

Operating mode	Vref	RF REG	VCOBBA	VBB	VSIM	SIMIF
Power off	Off	Off	Off	Off	Off	Pull down
Power on	On	On/Off	On	On	On	On/Off
Reset	On	Off VR1 On	On	On	Off	Pull down
Sleep	On	Off	Off	On	On	On/Off

NOTE: COBBA regulator is off in SLEEP mode. Its output pin may be fed from V_{BB} in SLEEP mode by setting bit RFReg(5) to '1' (default).

CCONT includes also five additional 2.8V regulators providing power to the RF section. These regulators can be controlled either by the direct control signals from MAD or by the RF regulator control register in CCONT which MAD can update. Below are the listed the MAD control lines and the regulators they are controlling.

- TxPwr controls **VTX regulator (VR5)**
- RxPwr controls **VRX regulator (VR2)**
- SynthPwr controls all the rf regulators except VR1
- VCXOPwr controls VXO regulator (VR1)

In additon to the above mentioned signals MAD includes also TXP control signal which goes to HAGAR power control block**.** The transmitter power control TXC is led from COBBA to HAGAR.

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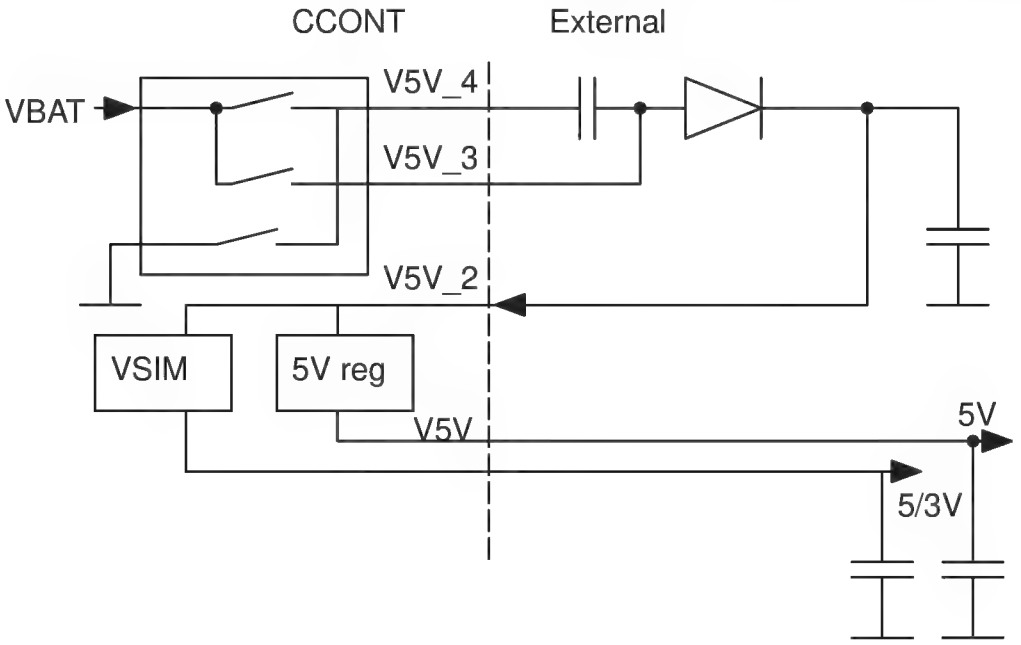
Switched Mode Supply VSIM

There is a switched mode supply for SIM–interface. SIM voltage is selected via serial IO. The 5V SMR can be switched on independently of the SIM voltage selection, but can't be switched off when VSIM voltage value is set to 5V.

NOTE: VSIM and V5V can give together a total of 30mA.

In the next figure the principle of the SMR / VSIM–functions is shown.



Power Up and Power Down

The baseband is powered up by:

1. Pressing the power key, that generates a PWRONX interrupt signal from the power key to the CCONT, which starts the power up procedure.
2. Connecting a charger to the phone. The CCONT recognizes the charger from the VCHAR voltage and starts the power up procedure.
3. A RTC interrupt. If the real time clock is set to alarm and the phone is switched off, the RTC generates an interrupt signal, when the alarm is gone off. The RTC interrupt signal is connected to the PWRONX line to give a power on signal to the CCONT just like the power key.
4. A battery interrupt. Intelligent battery packs have a possibility to power up the phone. When the battery gives a short (10ms) voltage pulse through the BTEMP pin, the CCONT wakes up and starts the power on procedure.

Power up with a charger

When the charger is connected CCONT will switch on the CCONT digital voltage as soon as the battery voltage exceeds 3.0V. The reset for

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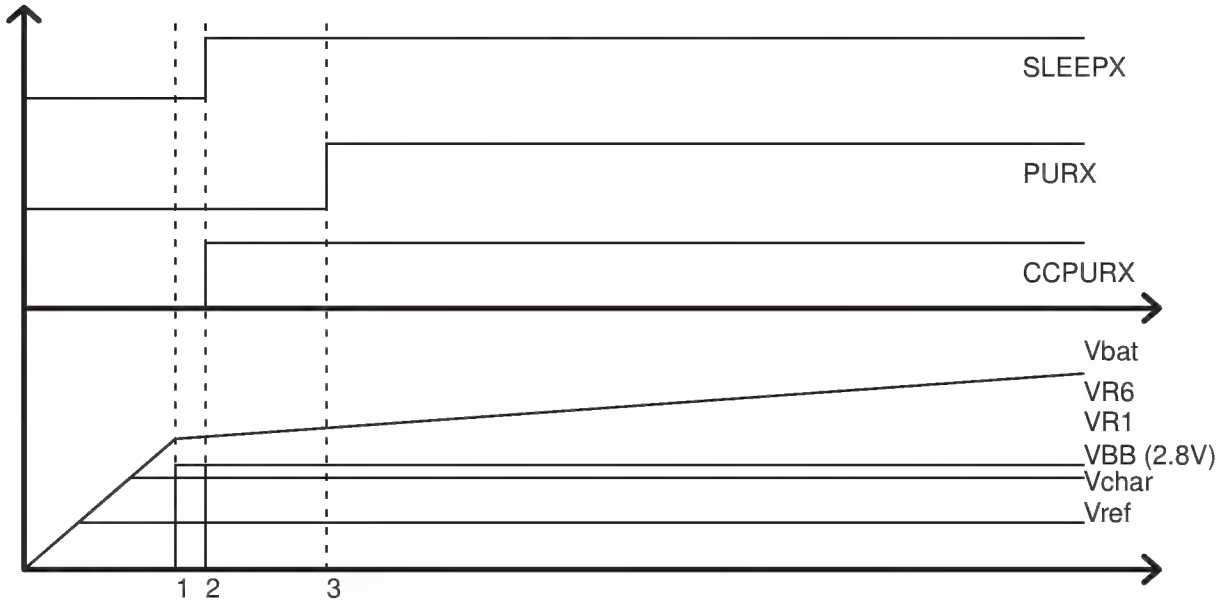
CCONT's digital parts is released when the operating voltage is stabilized (50 us from switching on the voltages). Operating voltage for VCXO is also switched on. The counter in CCONT digital section will keep MAD in reset for 62 ms (PURX) to make sure that the clock provided by VCXO is stable. After this delay MAD reset is relased, and VCXO –control (SLEEPX) is given to MAD. The next diagram explains the power on procedure with charger (the picture assumes empty battery, but the situation would be the same with full battery):



1: Battery voltage over 3.0==>Digital voltages to CCONT (VBB)
2: CCONT digital reset released. VCXO turned on
3: 62ms delay before PURX released

When the phone is powered up with an empty battery pack using the standard charger, the charger may not supply enough current for standard powerup procedure and the powerup must be delayed.

Power Up With The Power Switch (PWRONX)

When the power on switch is pressed the PWRONX signal will go low. CCONT will switch on the CCONT digital section and VCXO as was the case with the charger driven power up. If PWRONX is low when the 64 ms delay expires, PURX is released and SLEEPX control goes to MAD. If PWRONX is not low when 64 ms expires, PURX will not be released, and CCONT will go to power off (digital section will send power off signal to analog parts)

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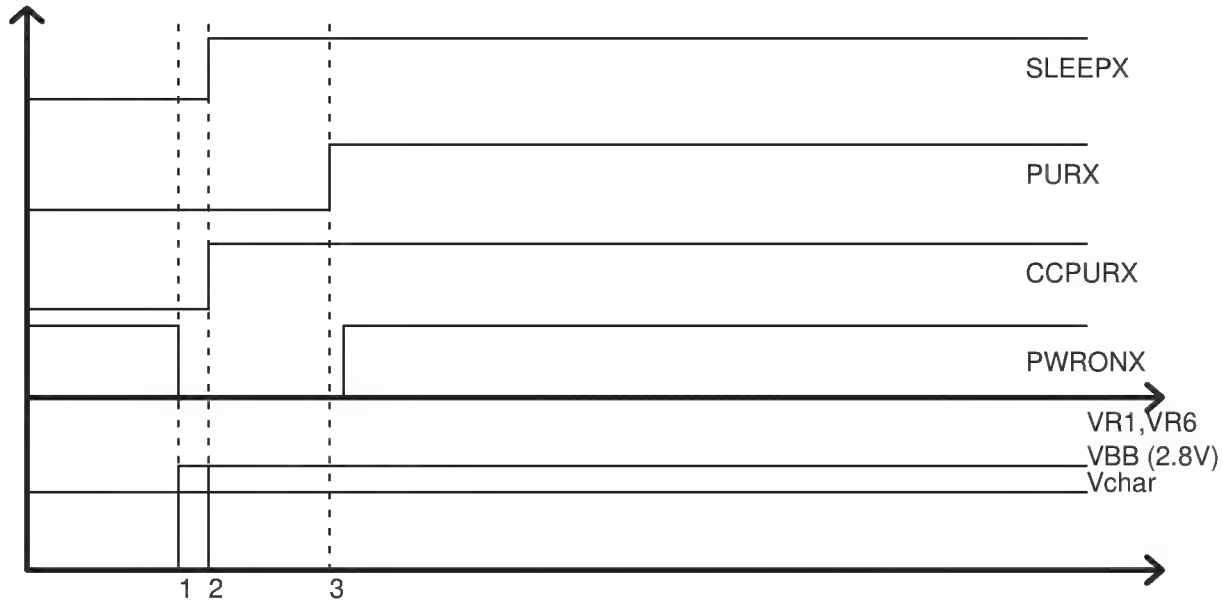

1:Power switch pressed ==> Digital voltages on in CCONT (VBB)
2: CCONT digital reset released. VCXO turned on
3: 62 ms delay to see if power switch is still pressed.

Power Up by RTC

RTC (internal in CCONT) can power the phone up by changing RTCPwr to logical 1.

Power Up by IBI

IBI can power CCONT up by giving a short pulse (10ms) through the BTEMP line. After powerup BTEMP will act as any other input channel for ADC.

When the PURX reset is released, the MAD releases the system reset ExtSysResetX and the internal MCUResetX signals and starts the boot program execution from MAD bootrom if MAD GenSDIO pin is pulled low or from external memory if GenSDIO pin is pulled high. In normal operation the program execution continues from the flash program memory. If the MBUS line is pulled low during the power up the bootrom starts a flash programming sequence and waits for the prommer response through FBUS_RX line.

Power Down

The baseband is powered down by:

1. Pressing the power key, that is monitored by the MAD, which starts the power down procedure.
2. If the battery voltage is dropped below the operation limit, either by not charging it or by removing the battery.
3. Letting the CCONT watchdog expire, which switches off all CCONT regulators and the phone is powered down.

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4. Setting the real time clock to power off the phone by a timer. The RTC generates an interrupt signal, when the alarm is gone off. The RTC interrupt signal is connected to the PWRONX line to give a power off signal to the CCONT just like the power key.

The power down is controlled by the MAD. When the power key has been pressed long enough or the battery voltage is dropped below the limit the MCU initiates a power down procedure and disconnects the SIM power. Then the MCU outputs a system reset signal and resets the DSP. If there is no charger connected the MCU writes a short delay to CCONT watchdog and resets itself. After the set delay the CCONT watchdog expires, which activates the PURX and all regulators are switched off and the phone is powered down by the CCONT.

If a charger is connected when the power key is pressed the phone enters into the acting dead mode.

Modes of Operation

Acting Dead

If the phone is off when the charger is connected, the phone is powered on but enters a state called "acting dead". To the user the phone acts as if it was switched off. A battery charging alert is given and/or a battery charging indication on the display is shown to acknowledge the user that the battery is being charged.

Active Mode

In the active mode the phone is in normal operation, scanning for channels, listening to a base station, transmitting and processing information. All the CCONT regulators are operating. There are several substates in the active mode depending on if the phone is in burst reception, burst transmission, if DSP is working etc.

Sleep Mode

In the sleep mode all the regulators except the baseband VBB and the SIM card VSIM regulators are off. Sleep mode is activated by the MAD after MCU and DSP clocks have been switched off. The voltage regulators for the RF section are switched off and the VCXO power control, VCXOPwr is set low. In this state only the 32 kHz sleep clock oscillator in CCONT is running. The flash memory power down input is connected to the ExtSysResetX signal, and the flash is deep powered down during the sleep mode.

The sleep mode is exited either by the expiration of a sleep clock counter in the MAD or by some external interrupt, generated by a charger connection, key press, headset connection etc. The MAD starts the wake up sequence and sets the VCXOPwr and ExtSysResetX control high. After VCXO settling time other regulators and clocks are enabled for active mode.

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If the battery pack is disconnect during the sleep mode, the CCONT pulls the SIM interface lines low as there is no time to wake up the MCU.

Charging

Charging can be performed in any operating mode.The battery type/size is indicated by a resistor inside the battery pack. The resistor value corresponds to a specific battery capacity. This capacity value is related to the battery technology as different capacity values are achieved by using different battery technology.

The battery voltage, temperature, size and current are measured by the CCONT controlled by the charging software running in the MAD.

The power management circuitry controls the charging current delivered from the charger to the battery. Charging is controlled with a PWM input signal, generated by the CCONT. The PWM pulse width is controlled by the MAD and sent to the CCONT through a serial data bus. The battery voltage rise is limited by turning the CHAPS switch off when the battery voltage has reached 4.2 V. Charging current is monitored by measuring the voltage drop across a 220 mohm resistor.

Watchdog

The Watchdog block inside CCONT contains a watchdog counter and some additional logic which are used for controlling the power on and power off procedures of CCONT. Watchdog output is disabled when WDDisX pin is tied low. The WD-counter runs during that time, though. Watchdog counter is reset internally to 32 s at power up. Normally it is reset by MAD writing a control word to the WDReg.

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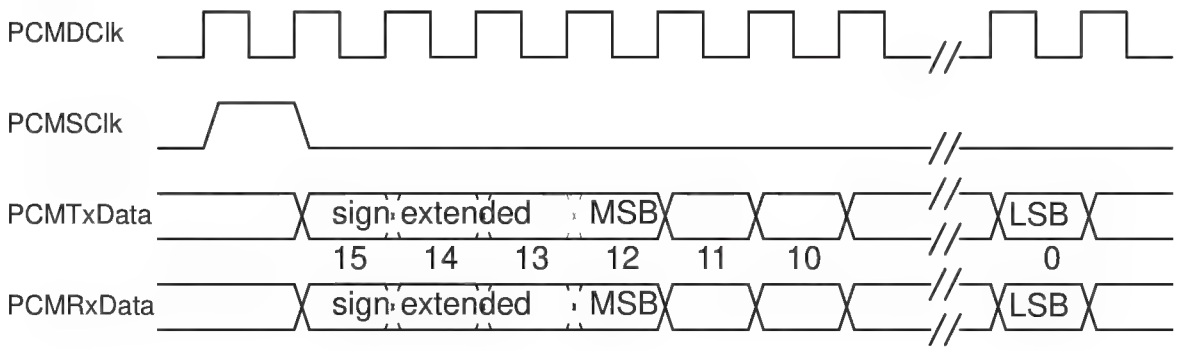
Audio control

PCM serial interface

The interface consists of following signals: a PCM codec master clock (PCMDClk), a frame synchronization signal to DSP (PCMSClk), a codec transmit data line (PCMTX) and a codec receive data line (PCMRX). The COBBA–GJP generates the PCMDClk clock, which is supplied to DSP SIO. The COBBA–GJP also generates the PCMSClk signal to DSP by dividing the PCMDClk. The PCMDClk frequency is 1.000 MHz and is generated by dividing the RFIClk 13 MHz by 13. The COBBA–GJP further divides the PCMDClk by 125 to get a PCMSClk signal, 8.0 kHz.



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Digital Control

The baseband functions are controlled by the MAD asic, which consists of a MCU, a system ASIC and a DSP.

MAD2 WD1

MAD2 WD1 contains following building blocks:

- ARM RISC processor with both 16–bit instruction set (THUMB mode) and 32–bit instruction set (ARM mode)
- TI Lead DSP core with peripherials:
    - API (Arm Port Interface memory) for MCU–DSP communication, DSP code download, MCU interrupt handling vectors (in DSP RAM) and DSP booting.
    - Serial port (connection to PCM)
    - Timer
    - DSP memory
- BUSC (BusController for controlling accesses from ARM to API, System Logic and MCU external memories, both 8– and 16–bit memories)
- System Logic
    - CTSI (Clock, Timing, Sleep and Interrupt control)
    - MCUIF (Interface to ARM via BusC). Contains MCU BootROM
    - DSPIF (Interface to DSP)
    - MFI (Interface to COBBA AD/DA Converters)
    - CODER (Block encoding/decoding and A51&A52 ciphering)
    - AccIF(Accessory Interface)
    - SCU (Synthesizer Control Unit for controlling 2 separate synthesizer)
    - UIF (Keyboard interface, serial control interface for COBBA PCM Codec, LCD Driver and CCONT)
    - SIMI (SimCard interface with enhanced features)
    - PUP (Parallel IO, USART and PWM control unit for vibra and buzzer)
    - Flexpool

The MAD2 operates from a 13 MHz system clock, which is generated from the 13Mhz VCXO frequency. The MAD2 supplies a 6,5 MHz or a 13 MHz internal clock for the MCU and system logic blocks and a 13 MHz clock for the DSP, where it is multiplied to 45.5 MHz DSP clock. The system clock can be stopped for a system sleep mode by disabling the VCXO supply power from the CCONT regulator output. The CCONT provides a 32 kHz sleep clock for internal use and to the MAD2, which is

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used for the sleep mode timing. The sleep clock is active when there is a battery voltage available i.e. always when the battery is connected.

Ball	Name	Pin Type	Connected to/from	Drive req. mA	Reset State	Note	Explanation
A1	MCUGemIO 0	O		2	0		MCU General purpose output port
C2	*LEADGND*						Lead Ground
D2	Col4	I/O	UIF	2	Input	program-mable pullup PR0201	I/O line for key-board column 4
D3	Col3	I/O	UIF	2	Input	program-mable pullup PR0201	I/O line for key-board column 3
H11	MCUGenIO1	I/O		2	Input, pullup	pullup PR0201	General purpose I/O port
E4	**GND**						Ground
D4	Col2	I/O	UIF	2	Input	program-mable pullup PR0201	I/O line for key-board column 2
C4	Col1	I/O	UIF	2	Input	program-mable pullup PR0201	I/O line for key-board column 1
C3	Col0	I/O	UIF	2	Input	program-mable pullup PR0201	I/O line for key-board column 0
D1	LCDCSX	I/O	UIF	2	Input	external pullup/down	serial LCD driver chip select, par-allel LCD driver enable
E1	*LEADVCC*						Lead Power
F12	*LoByteSelX*						NC
E3	Row5LCDCD	I/O	UIF	2	Input, pullup	pullup PR0201	Keyboard row5 data I/O , serial LCD driver com-mand/data indi-cator, parallel LCD driver read/ write select
N4	**VCC_CORE**					Core VCC in 3325c10	Power
E2	Row4	I/O	UIF	2	Input, pullup	pullup PR0201	I/O line for key-board row 4, par-allel LCD driver register selection control
F4	Row3	I/O	UIF	2	Input, pullup	pullup PR0201	I/O line for key-board row 3, par-allel LCD driver data

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Ball	Name	Pin Type	Connected to/from	Drive req. mA	Reset State	Note	Explanation
F3	Row2	I/O	UIF	2	Input, pullup	pullup PR0201	I/O line for keyboard row 2, parallel LCD driver data
F2	Row1	I/O	UIF	2	Input, pullup	pullup PR0201	I/O line for keyboard row 1, parallel LCD driver data
F1	Row0	I/O	UIF	2	Input, pullup	pullup PR0201	I/O line for keyboard row 0, parallel LCD driver data
L11	JTDO	O		2	Tri–state		JTAG data out
L5	**GND**						Ground
N12	JTRst	I			Input, pull-down	pulldown PD0201	JTAG reset
M12	JTClk	I			Input	pulldown PD0201	JTAG Clock
N13	JTDI	I			Input, pullup	pullup PR0201	JTAG data in
M13	JTMS	I			Input, pullup	pullup PR0201	JTAG mode select
G13	**VCC_IO**					IO VCC in 3325c10	Power
L12	CoEmu0	I/O		2	Input, pullup	pullup PR0201	DSP/MCU emulation port 0
L13	CoEmu1	I/O		2	Input, pullup	pullup PR0201	DSP/MCU emulation port 1
H4	*LEADGND*						Lead Ground
L1	*ARMGND*						ARM Ground
N3	MCUAd0	O	MCU MEMORY	2	0		MCU address bus
K4	*ARMVCC*						ARM Power
N2	MCUAd1	O	MCU MEMORY	2	0		MCU address bus
N1	MCUAd2	O	MCU MEMORY	2	0		MCU address bus
M4	MCUAd3	O	MCU MEMORY	2	0		MCU address bus
M3	MCUAd4	O	MCU MEMORY	2	0		MCU address bus
M2	MCUAd5	O	MCU MEMORY	2	0		MCU address bus
M1	MCUAd6	O	MCU MEMORY	2	0		MCU address bus

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Ball	Name	Pin Type	Connected to/from	Drive req. mA	Reset State	Note	Explanation
H1	**VCC_IO**					IO VCC in 3325c10	Power
L4	MCUAd7	O	MCU MEMORY	2	0		MCU address bus
L3	MCUAd8	O	MCU MEMORY	2	0		MCU address bus
L2	MCUAd9	O	MCU MEMORY	2	0		MCU address bus
K5	MCUAd10	O	MCU MEMORY	2	0		MCU address bus
J4	**GND**						Ground
K3	MCUAd11	O	MCU MEMORY	2	0		MCU address bus
K2	MCUAd12	O	MCU MEMORY	2	0		MCU address bus
K1	MCUAd13	O	MCU MEMORY	2	0		MCU address bus
J3	MCUAd14	O	MCU MEMORY	2	0		MCU address bus
J2	MCUAd15	O	MCU MEMORY	2	0		MCU address bus
J1	MCUAd16	O	MCU MEMORY	2	0		MCU address bus
M10	**VCC_CORE**					Core VCC in 3325c10	Power
H3	MCUAd17	O	MCU MEMORY	2	0		MCU address bus
H2	MCUAd18	O	MCU MEMORY	2	0		MCU address bus
G4	MCUAd19	O	MCU MEMORY	2	0		MCU address bus
G3	MCUAd20	O	MCU MEMORY	2	0		MCU address bus
G2	VCONT	O					
K6	ExtMCUDa0	I/O	MCU MEMORY	2	Input		MCU data bus
K9	**GND**						Ground
L6	ExtMCUDa1	I/O	MCU MEMORY	2	Output		MCU data bus
M6	ExtMCUDa2	I/O	MCU MEMORY	2	Output		MCU data bus
N6	ExtMCUDa3	I/O	MCU MEMORY	2	Output		MCU data bus
L7	ExtMCUDa4	I/O	MCU MEMORY	2	Output		MCU data bus

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Ball	Name	Pin Type	Connected to/from	Drive req. mA	Reset State	Note	Explanation
M7	ExtMCUDa5	I/O	MCU MEMORY	2	Output		MCU data bus
N7	ExtMCUDa6	I/O	MCU MEMORY	2	Output		MCU data bus
N8	ExtMCUDa7	I/O	MCU MEMORY	2	Output		MCU data bus
M8	MCUGenIODa0	I/O		2	Input	MCU Data in 16–bit mode	General purpose I/O port
L8	MCUGenIODa1	I/O		2	Input	MCU Data in 16–bit mode	General purpose I/O port
K8	MCUGenIODa2	I/O		2	Input	MCU Data in 16–bit mode	General purpose I/O port
N9	MCUGenIODa3	I/O		2	Input	MCU Data in 16–bit mode	General purpose I/O port
E10	**GND**						Ground
M9	MCUGenIODa4	I/O		2	Input	MCU Data in 16–bit mode	General purpose I/O port
L9	MCUGenIODa5	I/O		2	Input	MCU Data in 16–bit mode	General purpose I/O port
N10	MCUGenIODa6	I/O		2	Input	MCU Data in 16–bit mode	General purpose I/O port
L10	MCUGenIODa7	I/O		2	Input	MCU Data in 16–bit mode	General purpose I/O port
M5	MCURdX	O	MCU MEMORY	2	1		MCU Read strobe
G11	**VCC_CORE**					Core VCC in 3325c10	Power
N5	MCUWrX	O	MCU MEMORY	2	1		MCU write strobe
N11	ROM1SelX	O	MCU ROM	2	1		ROM chip select
M11	RAMSelX	O	MCU RAM	2	1		RAM chip select
J11	IRON	O	IR Mod	2	1		IR control
A1	MCUGenIO1	I/O		2	Input, pullup	pullup PR0201	General purpose I/O port
D8	DSPXF	O		2	1		External flag
K10	*SCVCC*						Special cell Power
K11	RFClk	I	VCXO		Input		System clock from VCTCXO
K12	RFClkGnd				Input		System clock reference ground input
K13	SIMCardDetX	I			Input		SIM card detection

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Ball	Name	Pin Type	Connected to/from	Drive req. mA	Reset State	Note	Explanation
J10	*SCGND*						Special cell Ground
D9	BuzzPWM	O	BUZZER	2	0		Buzzer PWM control
D11	*LEADVCC*						LEAD Power
G12	VibraPWM	O	VIBRA	2	0		Vibra PWM control
C9	**GND**						Ground
E12	MCUGenIO3	I/O		2	Input, pullup	pullup PR1001	General purpose I/O port
E13	MCUGenIO2	I/O		2	Input, pullup	pullup PR1001	General purpose I/O port
J13	KBLights	O	UIF	2	1		
C5	AccTxData	I/O		4	Tri–State	external pullup	Accessory TX data, Flash_TX
B6	**VCC_IO**					IO VCC in 3325c10	Power
F11	HookDet	I			Input		Non–MBUS accessory connection detector
F10	HeadDet	I			Input		Headset detection interrupt
D6	AccRxData	I			Input		Accessory RX data, Flash_RX
D5	**GND**						Ground
G10	MCUGenIO4	I/O		2	Input, pull-down	pulldown PD1001	General purpose I/O port
B5	MBUS	I/O		2	Input, external pullup	external pullup	MBUS, Flash clock
E11	VCXOPwr	O	CCONT	2	1		VCXO regulator control
D13	SynthPwr	O	CCONT	2	0		Synthesizer regulator control
B7	**VCC_CORE**					Core VCC in 3325c10	Power
C10	GenCCONTCSX	O	CCONT	2	1		Chip select to CCONT
F13	*LEADGND*						LEAD Ground
B10	GenSDIO	I/O	CCONT, UIF	2	Input, external pullup/down	external pullup/down depending on how to boot	Serial data in/out

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Ball	Name	Pin Type	Connected to/from	Drive req. mA	Reset State	Note	Explanation
A10	GenSClk	O	CCONT, UIF	2	0		Serial clock
C11	SIMCardData	I/O	CCONT	2	0		SIM data
J12	**GND**						Ground
B13	PURX	I	CCONT		Input		Power Up Reset
B12	CCONTInt	I	CCONT		Input		CCONT interrupt
A13	Clk32k	I	CCONT		Input		Sleep clock oscillator input
D10	**VCC_IO**					IO VCC in 3325c10	Power
A12	SIMCardClk	O	CCONT	2	0		SIM clock
B11	SIMCardRstX	O	CCONT	2	0		SIM reset
A11	SIMCardIOC	O	CCONT	2	0		SIM data in/out control
D12	SIMCardPwr	O	CCONT	2	0		SIM power control
H10	*LEADVCC*						LEAD Power
C13	RxPwr	O		2	0		(RX regulator control)
C12	TxPwr	O		2	0		(TX regulator control)
H12	TestMode	I			Input, pull-down	pulldown PD0201	Test mode select
H13	ExtSysResetX	O		2	0		System Reset
B9	PCMTxData	O	COBBA	2	0		Transmit data, DX
K7	**VCC_IO**					IO VCC in 3325c10	Power
A9	PCMRxData	I	COBBA		Input		Receive data, RX
B8	PCMDClk	I	COBBA		Input		Transmit clock, CLKX
A8	PCMSClk	I	COBBA		Input		Transmitframe sync, FSX
C6	COBBAClk	O	COBBA	4	1		COBBA clock, 13 MHz
A6	COBBACSX		COBBA				COBBA
A7	COBBASD		COBBA				COBBA
C7	IData		COBBA				COBBA
D7	QData		COBBA				COBBA
G1	**VCC_CORE**					Core VCC in 3325c10	Power

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Ball	Name	Pin Type	Connected to/from	Drive req. mA	Reset State	Note	Explanation
C1	DSPGenOut3	O	RF	2	0		DSP general purpose output
B4	DSPGenOut2	O	RF	2	0		DSP general purpose output
A4	DSPGenOut1	O	RF	2	0		DSP general purpose output
A5	DSPGenOut0	O	CRFU	2	0		DSP general purpose output
A3	FrACtrl	O	RF	2	0		RF front amplifier control
B3	SynthEna	O	HAGAR	2	0		Synthesizer data enable
B1	SynthClk	O	HAGAR	2	0		Synthesizer clock
B2	SynthData	O	HAGAR	2	0		Synthesizer data
A2	TxPA	O	HAGAR	2	0		Power amplifier control

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Memories

MAD memory configuration

The MAD2WD1 used in NSM–5 contains 16 kW RAM, and 80 kW ROM memory.

Memory

The MCU program code resides in an external flash program memory, which size is 32Mbits (2048k x 16bit). The MCU work (data) memory size is 4096 kbits (512k x 16bit). Flash and SRAM memory chips are packed in same combo memory package.

The BusController (BUSC) section in the MAD decodes the chip select signals for the external memory devices and the system logic. BUSC controls internal and external bus drivers and multiplexers connected to the MCU data bus. The MCU address space is divided into access areas with separate chip select signals. BUSC supports a programmable number of wait states for each memory range.

Program and Data Memory

The MCU program code resides in the program memory. The program memory is 32Mbits (2048k x 16bit) Flash memory.

The flash memory has a power down pin that should be kept low, during the power up phase of the flash to ensure that the device is powered up in the correct state, read only. The power down pin is utilized in the system sleep mode by connecting the ExtSysResetX to the flash power down pin to minimize the flash power consumption during the sleep.

Nonvolatile data memory is implemented with program (Flash) memory. Special EEPROM emulation (EEEMmu) software is utilized.

Work Memory

The work memory is a static RAM of size 4096k (512k x 16). The memory contents are lost when the baseband voltage is switched off. All retainable data must be stored into the data memory when the phone is powered down.

MCU Memory Requirements

Device	Organization	Access Time ns	Wait States Used	Remarks
FLASH	2048kx16	120	1	uBGA 48
SRAM	512kx16	120	1	uBGA 48

MCU Memory Map

MAD2 supports maximum of 4GB internal and 4MB external address space. External memories use address lines MCUAd0 to MCUAd21 and

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8–bit/16–bit databus. The BUSC bus controller supports 8– and 16–bit access for byte, double byte, word and double word data. Access wait states (0, 1 or 2) and used databus width can be selected separately for each memory block.

Flash Programming

The phone have to be connected to the flash loading adapter so that supply voltage for the phone and data transmission lines can be supplied from/to the adapter. When adapter switches supply voltage to the phone, the program execution starts from the BOOT ROM and the MCU investigates in the early start–up sequence if the flash prommer is connected. This is done by checking the status of the MBUS–line. Normally this line is high but when the flash prommer is connected the line is forced low by the prommer.

The flash prommer serial data receive line is in receive mode waiting for an acknowledgement from the phone. The data transmit line from the baseband to the prommer is initially high. When the baseband has recognized the flash prommer, the TX–line is pulled low. This acknowledgement is used to start to toggle MBUS (FCLK) line three times in order that MAD2 gets initialized. This must be happened within 15 ms after TX line is pulled low. After that the data transfer of the first two bytes from the flash prommer to the baseband on the RX–line must be done within 1 ms.

When MAD2 has received the secondary boot byte count information, it forces TX line high. Now, the secondary boot code must be sent to the phone within 10 ms per 16 bit word. If these timeout values are exceeded, the MCU (MAD2) starts normal code execution from flash. After this, the timing between the phone and the flash prommer is handled with dummy bites.

A 5V programming voltage is supplied inside the transceiver from the battery voltage with a switch mode regulator (5V/30mA) of the CCONT. The 5V is connected to VPP pin of the flash.

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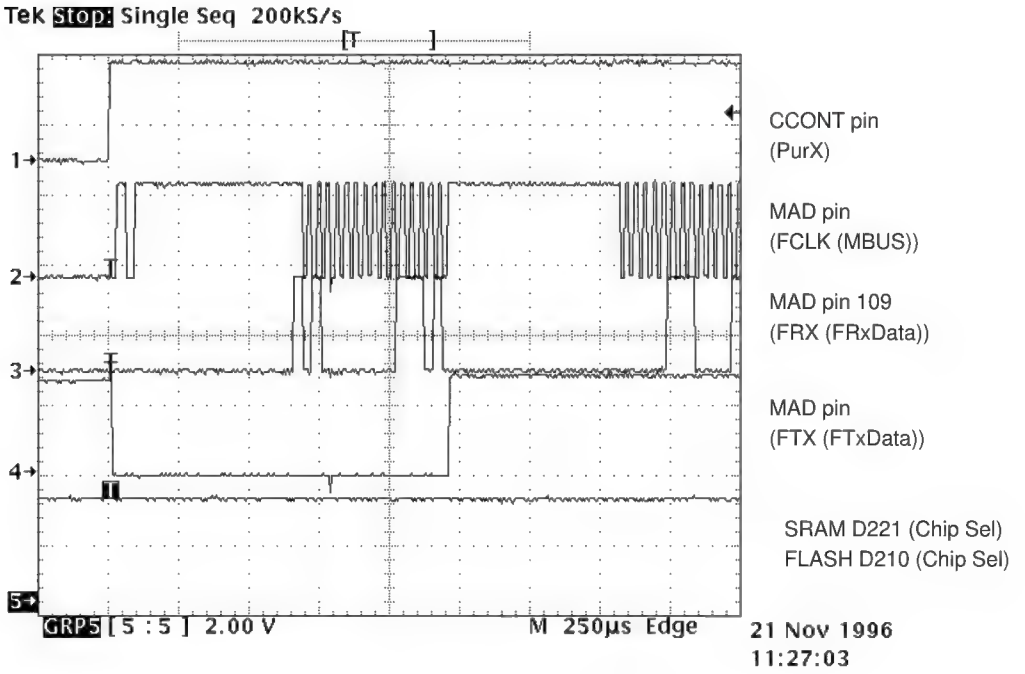
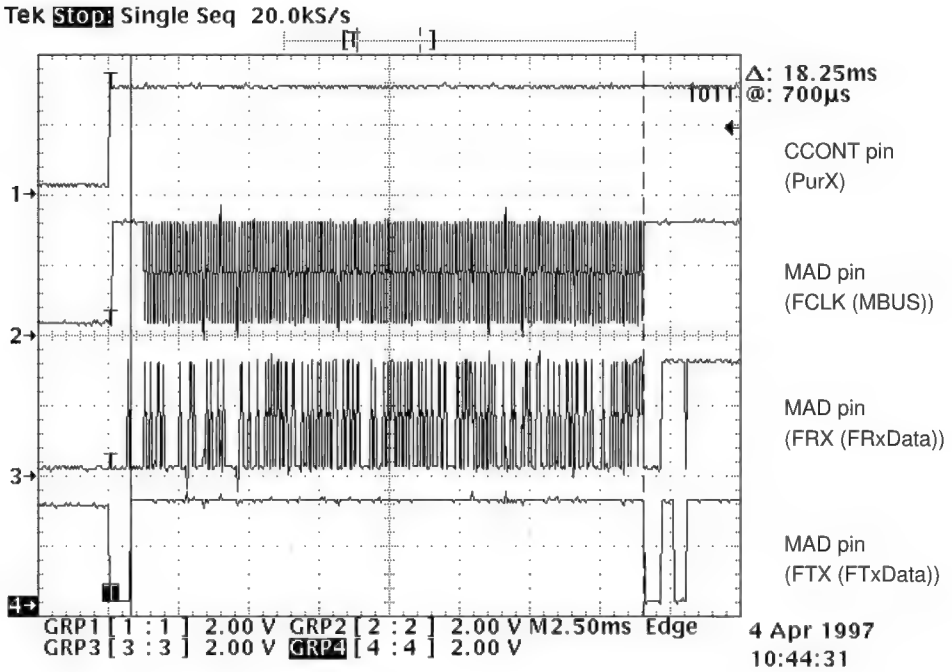
Flash Programming Sequence

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Δ: 18.25ms
@: 700µs
CCONT pin
(PurX)
MAD pin
(FCLK (MBUS))
MAD pin
(FRX (FRxData))
MAD pin
(FTX (FTxData))
GRP1 [1 : 1] 2.00 V GRP2 [2 : 2] 2.00 V M2.50ms Edge
GRP3 [3 : 3] 2.00 V GRP4 [4 : 4] 2.00 V
4 Apr 1997
10:44:31

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COBBA GJP

COBBA GJP ASIC provides an interface between the baseband and the RF–circuitry. COBBA performs analogue to digital conversion of the receive signal. For transmit path COBBA performs digital to analogue conversion of the transmit amplifier power control ramp and the in–phase and quadrature signals. A slow speed digital to analogue converter will provide automatic frequency control (AFC).

COBBA is at any time connected to MAD asic with two interfaces, one for transferring TX and RX data between MAD and COBBA and one for transferring codec RX/TX samples.

Real Time Clock

Requirements for a real time clock implementation are a basic clock (hours and minutes), a calender and a timer with alarm and power on/off –function and miscellaneous calls. The RTC will contain only the time base and the alarm timer but all other functions (e.g. calendar) will be implemented with the MCU software. The RTC needs a power backup to keep the clock running when the phone battery is disconnected. The backup power is supplied from a rechargable polyacene battery that can keep the clock running some ten minutes. If the backup has expired, the RTC clock restarts after the main battery is connected. The CCONT keeps MCU in reset until the 32kHz source is settled (1s max).

The CCONT is an ideal place for an integrated real time clock as the asic already contains the power up/down functions and a sleep control with the 32kHz sleep clock, which is running always when the phone battery is connected. This sleep clock is used for a time source to a RTC block.

RTC backup battery charging

CHAPS has a current limited voltage regulator for charging a backup battery. The regulator derives its power from VOUT so that charging can take place without the need to connect a charger. The backup battery is only used to provide power to a real time clock when VOUT is not present so it is important that power to the charging circuitry is derived from VOUT and that the charging circuitry does not present a load to the backup battery when VOUT is not present.

It should not be possible for charging current to flow from the backup battery into VOUT if VOUT happens to be lower than VBACK. Charging current will gradually diminish as the backup battery voltage reaches that of the regulation voltage.

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RF Module

This RF module takes care of all RF functions of EGSM/DCS1800 dual-band engine. RF circuitry is located on one side of the 8 layer tranceiver–PWB. PWB area for the RF circuitry is about 15 cm2. The RF design is based on the first dualband direct conversion RF–IC "Hagar". So there is no intermediate frequency and that means the number of component is much lover than before and there shall be much less interference problems than previously.

EMC emissions are taken care of using metallized plactic shield, which screens the whole transceiver. Internal screening is realized with isolated partitions. At least the VCO is isolated. The baseband circuitry is located on the same side of the same board.

Maximum Ratings

Parameter	Rating
Battery voltage, idle mode	4.2 V
Regulated supply voltage	2.8 +/– 3% V
Voltage reference	1.5 +/– 1.5% V
Operating temperature range	–10...+55 deg. C
Absolute maximum battery voltage	4.8 V

RF Characteristics

Item	Values (EGSM / DCS1800)
Receive frequency range	925 ... 960 MHz / 1805 ... 1880 MHz
Transmit frequency range	880 ... 915 MHz / 1710 ... 1785 MHz
Duplex spacing	45 MHz / 95 MHz
Channel spacing	200 kHz
Number of RF channels	174 / 374
Power class	4 (EGSM900) / 1 (DCS1800)
Number of power levels	15 / 16

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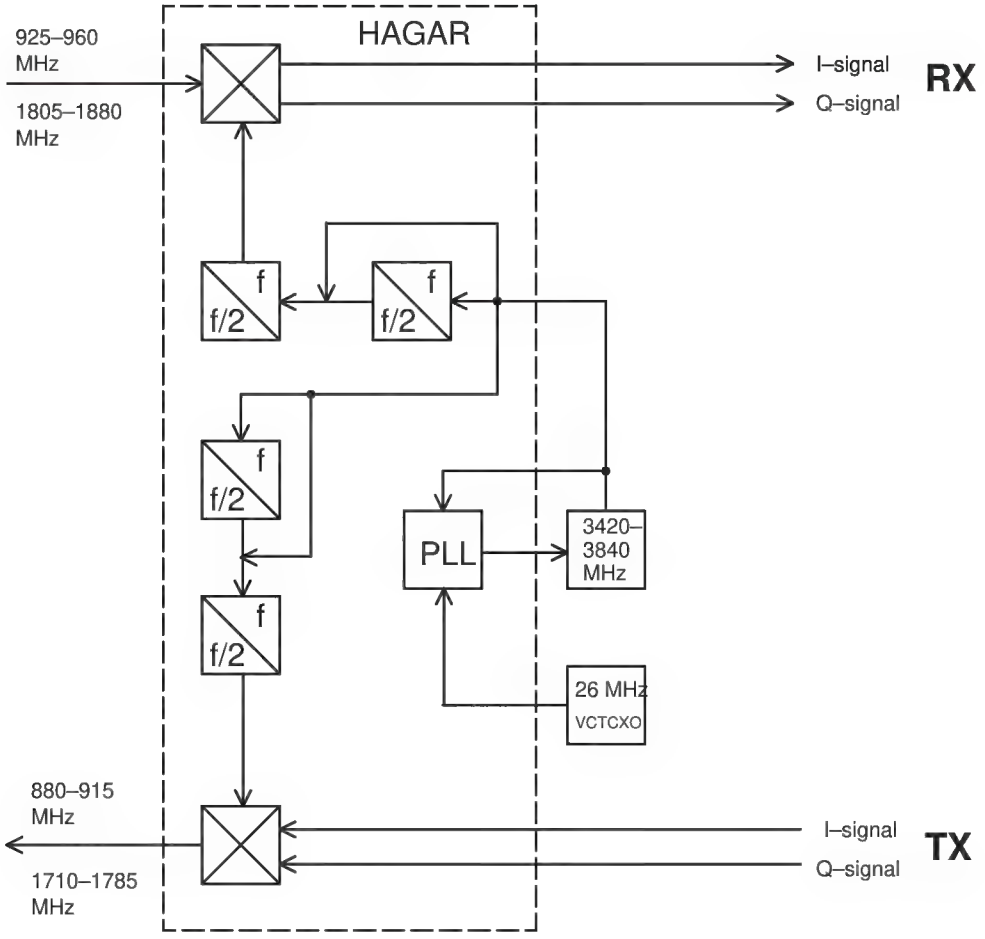
RF Frequency Plan



DC characteristics

Regulators

Transceiver has a multi function power management IC at baseband section, which contains among other functions, also 7 pcs of 2.8 V regulators. All regulators can be controlled individually with 2.8 V logic directly or through control register. In GSM direct controls are used to get fast switching, because regulators are used to enable RF–functions.

VREF_2 from CCONT IC and RXREF from COBBA IC are used as the reference voltages for HAGAR RF–IC, VREF_2 (1.5V) for bias reference and RXREF (1.2V) for RX ADC's reference.

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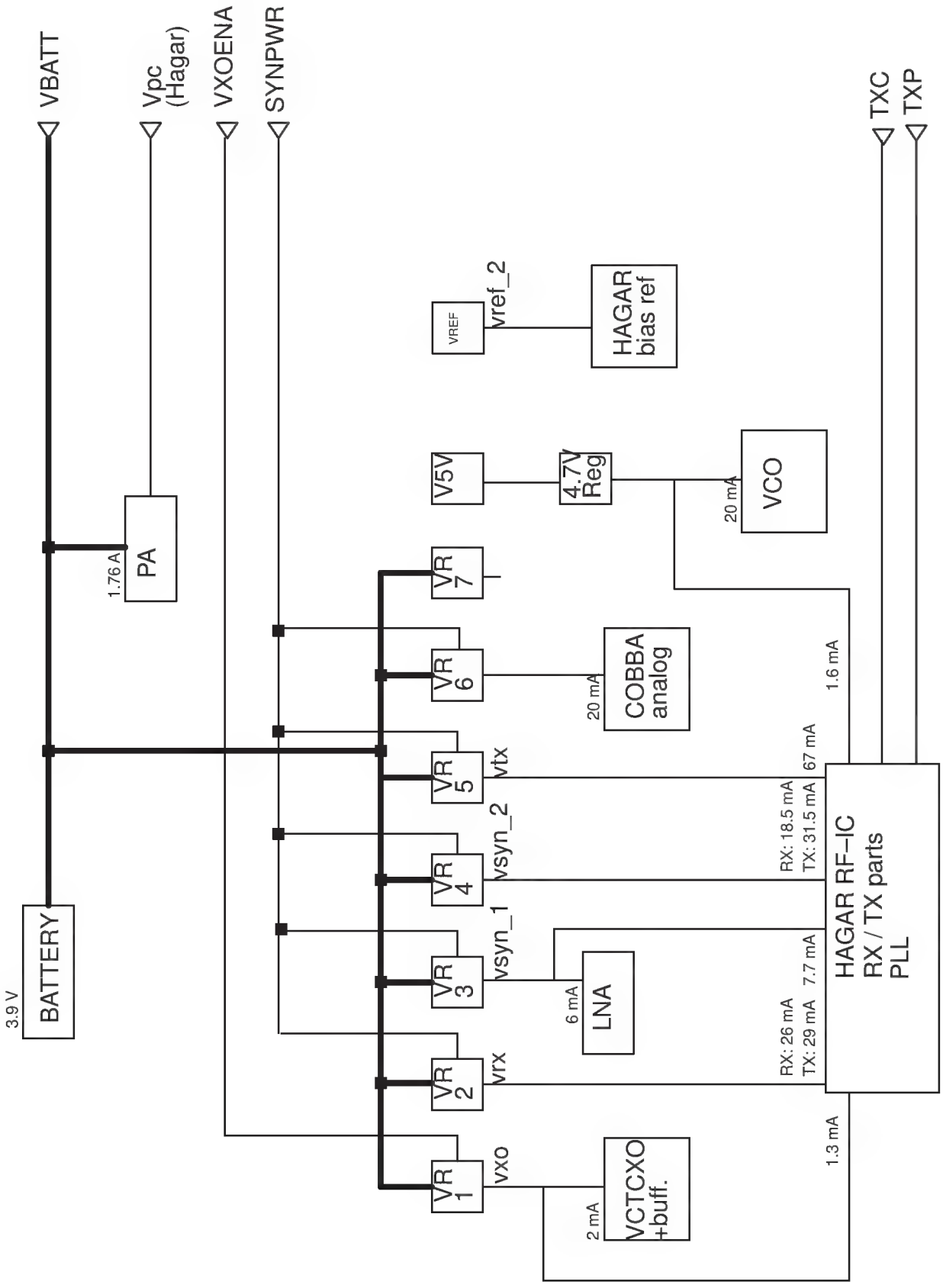
Power Distribution Diagram



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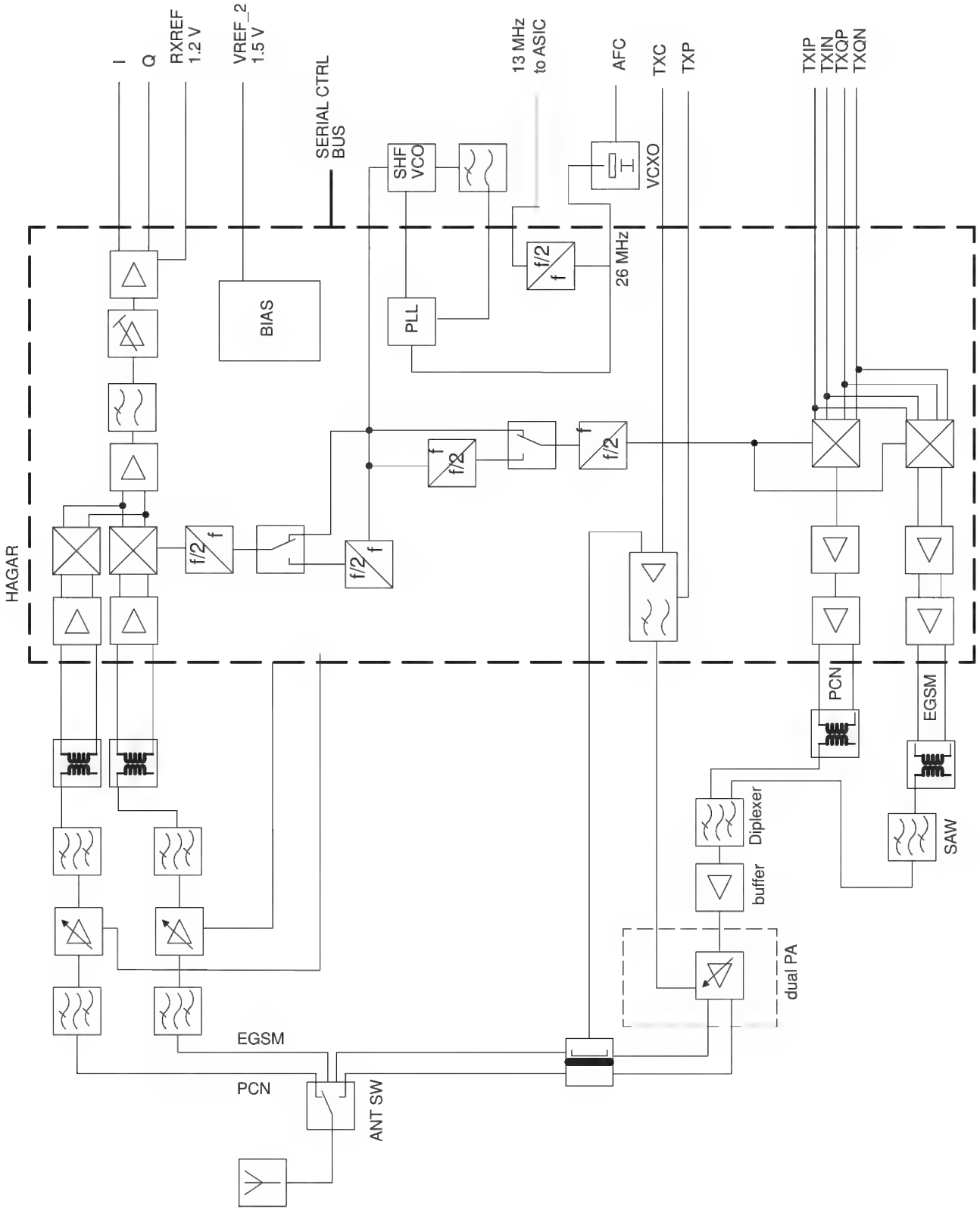
RF Functional Description

Architecture contains one RF–IC, dualband PA module, VCO–module, VCTCXO module and discrete LNA stages for both receive bands.



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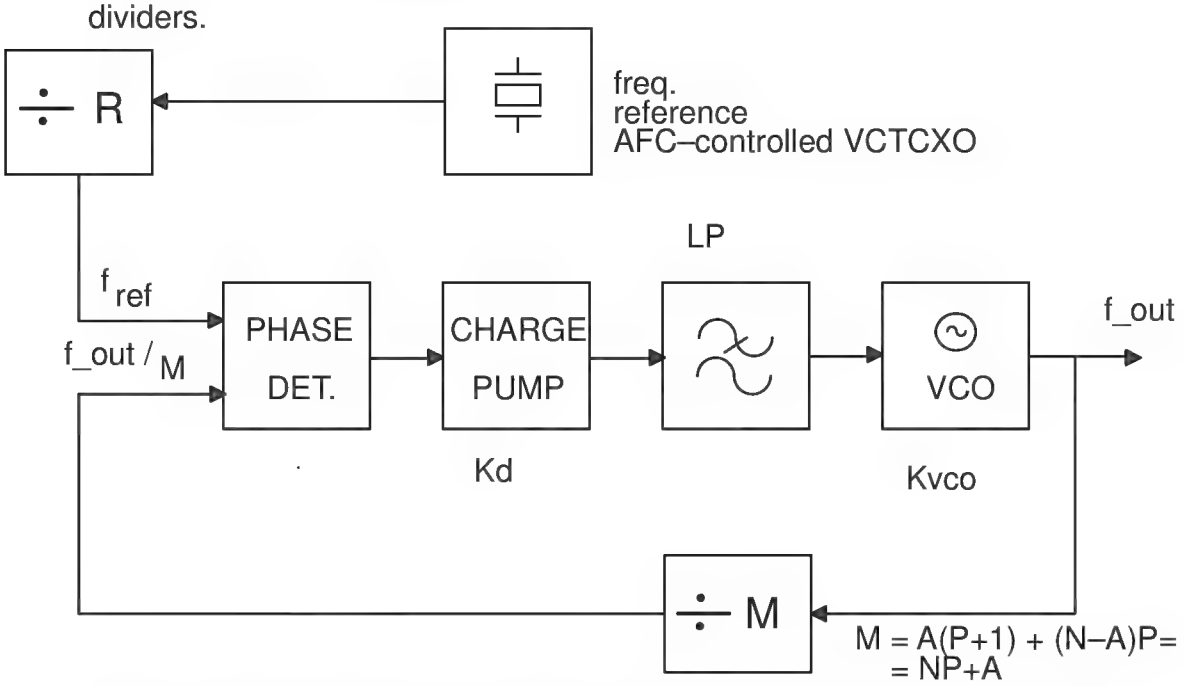
Frequency synthesizer

VCO frequency is locked with PLL into stable frequency source, which is a VCTCXO–module (voltage controlled temperature compensated crystal oscillator). VCTCXO is running at 26 MHz. Temperature effect is controlled with AFC (automatic frequency control) voltage. VCTCXO is locked into frequency of the base station. AFC is generated by baseband with a 11 bit conventional DAC in COBBA.

PLL is located in HAGAR RF–IC and is controled via serial bus from COBBA–IC (baseband).

There are 64/65 (P/P+1) prescaler, N– and A–divider, reference divider, phase detector and charge pump for the external loop filter. SHF local signal, generated by a VCO–module (VCO = voltage controlled oscillator), is fed to prescaler. Prescaler is a dual modulus divider. Output of the prescaler is fed to N– and A–divider, which produce the input to phase detector. Phase detector compares this signal to reference signal (400kHz), which is divided with reference divider from VCTCXO output. Output of the phase detector is connected into charge pump, which charges or discharges integrator capacitor in the loop filter depending on the phase of the measured frequency compared to reference frequency.

Loop filter filters out the pulses and generates DC control voltage to VCO. Loop filter defines step response of the PLL (settling time) and effects to stability of the loop, that's why integrator capacitor has got a resistor for phase compensation. Other filter components are for sideband rejection. Dividers are controlled via serial bus. SDATA is for data, SCLK is serial clock for the bus and SENA1 is a latch enable, which stores new data into dividers.



LO–signal is generated by SHF VCO module. VCO has double frequency in DCS1800 and x 4 frequency in EGSM compared to actual RF channel frequency. LO signal is divided by two or four in HAGAR (depending on system mode).

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Receiver

Receiver is a direct conversion, dualband linear receiver. Received RF–signal from the antenna is fed via RF–antenna switch to 1st RX dualband SAW filter and discrete LNAs (low noise amplifier), separate LNA branches for EGSM900 and DCS1800. Gain selection control of LNAs comes from HAGAR IC. Gain step is activated when RF–level in antenna is about –43 dBm.

After the LNA amplified signal (with low noise level) is fed to bandpass filter (2nd RX dualband SAW filter). RX bandpass filters defines how good are the blocking characteristics against spurious signals outside receive band and the protection against spurious responses.

These bandpass filtered signals are then balanced with baluns. Differential RX signal is amplified and mixed directly down to BB frequency in HAGAR. Local signal is generated with external VCO. VCO signal is divided by 2 (DCS1800) or by 4 (EGSM900). PLL and dividers are in HAGAR–IC.

From the mixer output to ADC input RX signal is divided into I– and Qsignals. Accurate phasing is generated in LO dividers. After the mixer DTOS amplifiers convert the differential signals to single ended. DTOS has two gain stages. The first one has constant gain of 12dB and 85kHz cut off frequency. The gain of second stage is controlled with control signal g10. If g10 is high (1) the gain is 6dB and if g10 is low (0) the gain of the stage is –4dB.

The active channel filters in HAGAR provides selectivity for channels (–3dB @ +/–100 kHz typ.). Integrated base band filter is active–RC–filter with two off–chip capacitors. Large RC–time constants needed in the channel select filter of direct conversion receiver are produced with large off–chip capacitors because the impedance levels could not be increased due to the noise specifications. Baseband filter consists of two stages, DTOS and BIQUAD. DTOS is differential to single–ended converter having 8dB or 18dB gain. BIQUAD is modified Sallen–Key Biquad.

Integrated resistors and capacitors are tunable. These are controlled with a digital control word. The correct control words that compensate for the process variations of integrated resistors and capacitors and of tolerance of off chip capacitors are found with the calibration circuit.

Next stage in the receiver chain is AGC–amplifier, also integrated into HAGAR. AGC has digital gain control via serial mode bus from COBBA IC. AGC–stage provides gain control range (40 dB, 10 dB steps) for the receiver and also the necessary DC compensation. One 10 dB AGC step is implemented in DTOS stages.

DC compensation is made during DCN1 and DCN2 operations (controlled via serial bus). DCN1 is carried out by charging the large external capacitors in AGC stages to a voltage which cause a zero dc–offset. DCN2 set the signal offset to constant value (RXREF 1.2 V). The RXREF signal (from COBBA GJP) is used as a zero level to RX ADCs.

Single ended filtered I/Q–signal is then fed to ADCs in COBBA–IC. Input level for ADC is 1.4 Vpp max.

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Transmitter

Transmitter chain consists of final frequency IQ–modulator, dualband power amplifier and a power control loop.

I– and Q–signals are generated by baseband also in COBBA–ASIC. After post filtering (RC–network) they go into IQ–modulator in HAGAR. LO–signal for modulator is generated by VCO and is divided by 2 or by 4 depending on system mode, EGSM/DCS1800. After modulator the TX–signal is amplified and buffered. There are separate outputs for both EGSM and DCS1800. HAGAR TX output level is 5 dBm minimum.

Next TX signals are converted to single ended by discrete baluns. EGSM and DCS1800 branches are compined at a diplexer. In EGSM branch there is a SAW filter before diplexer to attenuate unwanted signals and wideband noise from the Hagar IC.

The final amplication is realized with dualband power amplifier. It has one 50 ohm input and two 50 ohm outputs. There is also a gain control, which is controlled with a power control loop in HAGAR. PA is able to produce over 2 W (3 dBm input level) in EGSM band and over 1 W (6 dBm input level) in DCS1800 band into 50 ohm output. Gain control range is over 35 dB to get desired power levels and power ramping up and down.

Harmonics generated by the nonlinear PA are filtered out with the diplexer inside the antenna switch–module.

Power control circuitry consists of discrete power detector (common for EGSM and DCS1800) and error amplifier in HAGAR. There is a directional coupler connected between PA output and antenna switch. It is a dualband type and has input and outputs for both systems. Dir. coupler takes a sample from the forward going power with certain ratio. This signal is rectified in a schottky–diode and it produces a DC–signal after filtering.

This detected voltage is compared in the error–amplifier in HAGAR to TXC–voltage, which is generated by DA–converter in COBBA. TXC has got a raised cosine form ($\cos^4$ – function), which reduces switching transients, when pulsing power up and down. Because dynamic range of the detector is not wide enough to control the power (actually RF output voltage) over the whole range, there is a control named TXP to work under detected levels. Burst is enabled and set to rise with TXP until the output level is high enough, that feedback loop works. Loop controls the output via the control pin in PA to the desired output level and burst has got the waveform of TXC–ramps. Because feedback loops could be unstable, this loop is compensated with a dominating pole. This pole decreases gain on higher frequencies to get phase margins high enough. Power control loop in HAGAR has two outputs, one for both freq. bands.

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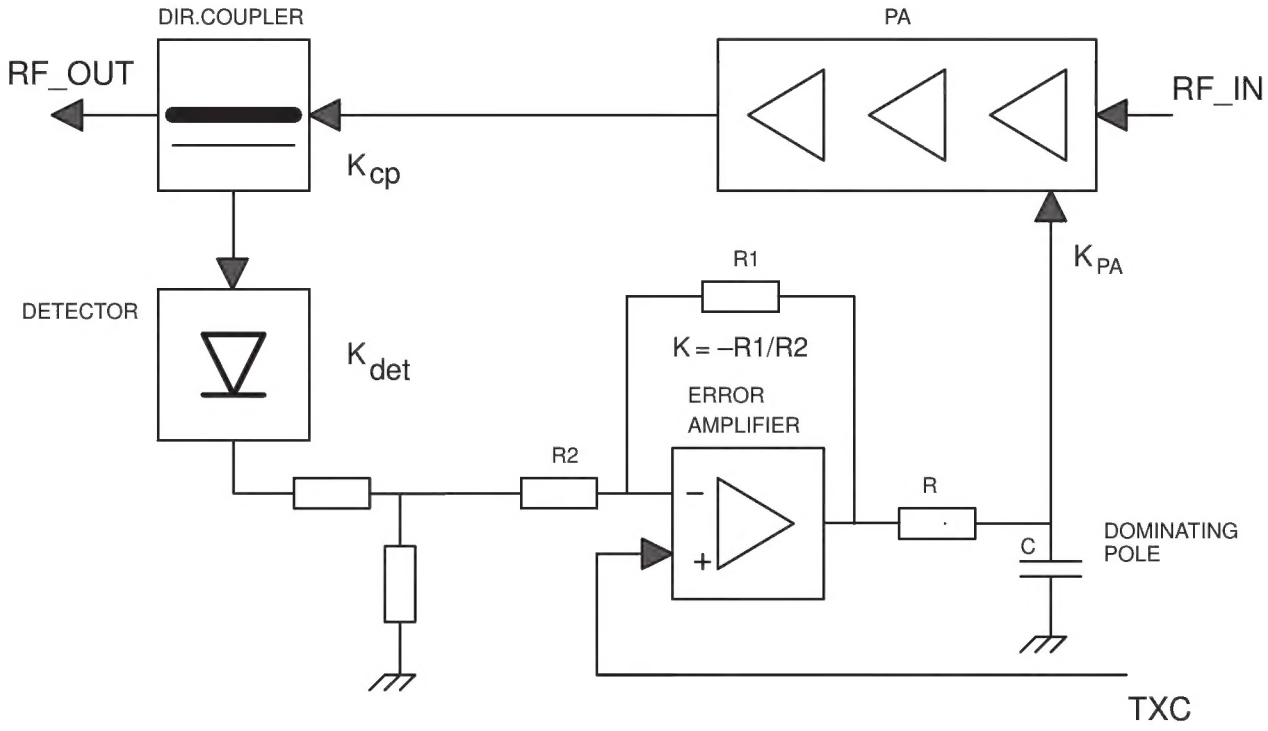

AGC strategy

AGC–amplifier is used to maintain output level of the receiver in certain range. AGC has to be set before each received burst, this is called pre–monitoring.

There is 50 dB accurate gain control (10 dB steps) and one larger step (~30 dB) in LNA. LNA AGC step size depends on channel with some amount.

RSSI must be measured accurately on range –48...–110 dBm. After –48 dBm level MS reports to base station the same reading.

Production calibration is done with two RF–levels, LNA gain step is not calibrated.

AFC function

AFC is used to lock the transceivers clock to frequency of the base station. AFC–voltage is generated in COBBA with 11 bit DA–converter. There is a RC–filter in AFC control line to reduce the noise from the converter. Settling time requirement for the RC–network comes from signalling, how often PSW (pure sine wave) slots occur. They are repeated after 10 frames, meaning that there is PSW in every 46 ms. AFC tracks base station frequency continously, so transceiver has got a stable frequency, because changes in VCTCXO–output don't occur so fast (temperature).

Settling time requirement comes also from the start up–time allowed. When transceiver is in sleep mode and "wakes" up to receive mode, there is only about 5 ms for the AFC–voltage to settle. When the first burst

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comes in system clock has to be settled into +/– 0.1 ppm frequency accuracy. The VCTCXO–module requires also 5 ms to settle into final frequency. Amplitude rises into full swing in 1...2 ms, but frequency settling time is higher so this oscillator must be powered up early enough.

DC–compensation

DC compensation is made during DCN1 and DCN2 operations (controlled via serial bus). DCN1 is carried out by charging the large external capacitors in AGC stages to a voltage which cause a zero dc–offset. DCN2 set the signal offset to constant value (RXREF 1.2 V).

Receiver characteristics

Item	Values
Type	Direct conversion, Linear, DualBand, FDMA/TDMA
LO frequencies	3700 ... 3840 MHz / 3610 ... 3760 MHz
Typical 3 dB bandwidth	+/– 104 kHz
Sensitivity	min. – 102 / – 102 dBm (EGSM/PCN) , S/N >8 dB
Total typical receiver voltage gain (from antenna to RX ADC)	90 dB
Receiver output level (RF level –95 dBm)	350 mVpp , single ended I/Q–signals to RX ADCs
Typical AGC dynamic range	80 dB
Accurate AGC control range	50 dB
Typical AGC step in LNA	30 dB
Usable input dynamic range	–102 ... –10 dBm
RSSI dynamic range	–110 ... –48 dBm
Compensated gain variation in receiving band	+/– 1.0 dB

Transmitter characteristics

Item	Values
Type	Direct conversion, dualband, non–linear, FDMA/TDMA
LO frequency range	3520 ... 3660 / 3420 ... 3570 MHz
Output power	2 W / 1 W peak
Gain control range	min. 30 dB
Maximum phase error (RMS/peak)	max 5 deg./20 deg. peak

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